

Cooling Tower IPSC

Nissen
6/8/05

Concrete Repair & Protection

Reinstructa Corp.

presentation
by Bruce

Bruce Collins Program Manager

Tim Gummig - president

Cris Wright - office manager

Guy Boulden - field operations * 18A pedestal

Dennis Pinelle - Corrosion Eng

Project History

fall 2000

Roof deck + fin stack

chloride content

Roof - top deck (No expansion joints above precast)
reflected cracks / early age cracking

fin stack - vapor drive / carbonation related corrosion
15%

Priority / cost estimate /

sealants + epoxy / water tight

Sikar sealer

core samples

U1 4-7/2001

U2 8-11/2001

Now

Roof deck ~~more~~ cracks / epoxy coating (to protect cracks)
gravity seal / surface applied

rust (iron oxide) staining - corrosion going on
cored over crack

U1 Senstack repair 3-6/2005

24 stacks / 25 days

Scaffolding (access platform) // built (~~test~~ ^{Save to wear U2})

Joint - remove grout / bond line grout (water curing - flow)
Created barrier

epoxy injection on cracks 2000 ft
wasn't debonding

Con am - future spalling

→ (Stacks - above blades concrete pretty good
con am - vertical joints upper - pre cast
some minor repair lower - cast in place (poorer concrete quality)
debonding / shrinkage of grouting

epoxy coating? / water proof wet here power wash 2 coat sealant

ongoing - take quad o/s

2 part - interior lot / then external

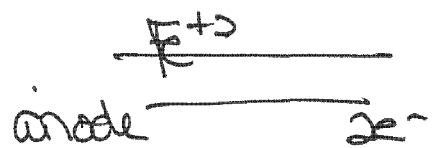
sacrificial anodes (Zn) heavy packs ^{Suppose to absorb / No volumetric change}
1 pH next to 4 pH opt pH for copy of presentation

Can install monitoring kit (corrosion rate get currents

10yr warranty - for repairs

sandblast / then charcoal Senstack (like govt rec)
vapor transfer

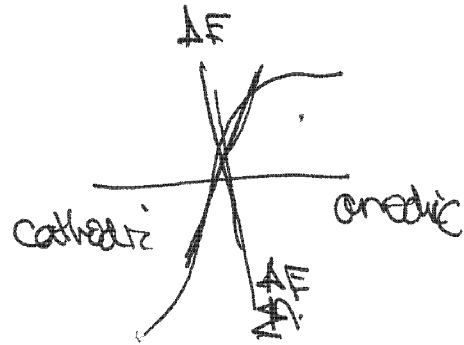
non destructive testing
Corrosion potential / - steel



3/4 over

1/2 cell potential
add small current applied

Corrosion current calc
1 linear potential



Corrosion measurement grid

Survey Test Results

U2 reference - baseline

location	Corrosion potential (mv)	Corrosion rate $\mu\text{m}/\text{year}$	Concrete test data (Kohm)
	less is better	corrosion currents repair & seal drops rate	down better drying out

~~Need for Corrosion~~

anode
cathode
moisture
 O_2

Northside - damper

15% - depth of concrete repair if deeper than 1" OK

over

12/2000 \$2.8m CS/moat

today \$1.34M

U1 U2 decks
U1 Finstacks

remaining ~\$1.46M

U2 Finstacks \$750K 2008
~~\$625K~~

add epoxy injection to top bars (stock + 75K 6/5 4/06)

spall repair 50K (lower assembly)
could be problem with

Other stuff \$50K-700K

U1/U2 - twintees
floor beams
chalking @ joints
base chalking
stitch exterior
every 5 yrs \$50K concrete tank stock
+ \$50K floor

Motor ~~stop~~ pedals
repair (add grades)
seal

Discuss Rest of CT Rust Protection

Impressed current Cathodic Protection
\$2M/CT maintenance H₂ embrittlement

Need to increase priority on Twintees support structure
→ Need Proposal for Concrete Repairs
Prepare report (rework presentation) where its an annual survey
Need to complete U2 (haven't start yet)
+ ongoing repairs

→ Annual Survey / need a summary report
→ still completing

Capital Expenditures working
→ need to maintain them

Executive Summary

The cooling tower roof deck and fan stack assemblies were investigated to determine causes of concrete deterioration. The investigation consisted of testing to find latent defects in the concrete and construction. Testing was also completed to find imposed deterioration mechanisms.

Testing of the twin tee tilt-up enclosure panels is underway and will be reported to Intermountain Power on approximately December 1, 2000.

The cooling tower roof deck is deteriorating due to poor original construction detailing. Localized reinforcing steel corrosion is occurring and accelerating due to early age cracking that occurred in the concrete topping slab. The cracks occur over joints in pre-cast concrete panels used to construct the roof. Localized concrete repair, coupled with crack repair and protection should be undertaken in a systematic manner. Proper repair procedures will provide the twenty-five year service life required for this structural component.

The fan stack assemblies also have localized concrete deterioration, mainly corrosion of reinforcing steel. This deterioration is generally caused by the condensation of the cooling tower water. Cracks and other "voids" in the assembly allow the condensed water to attack the fan stack concrete. These assemblies are not critical to the structural functioning of the cooling tower. Again, proper localized concrete repair coupled with crack repair and protection will provide the twenty-five year service life required.

The enclosed report, photographs and test results detail our findings.

Sincerely,

Bruce A. Collins
Vice President, Business Development

Introduction

The IPP cooling towers, Units 1A, 1B, 2A, 2B are constructed using primarily pre-cast concrete members. Cast in place concrete was used to build the basin, some interior walls, and a topping for the roof structure. A cast in place basin holds the cooling water. Interior pre-cast columns run full height supporting an intermediate floor and the roof deck. The intermediate floor system, constructed of pre-cast members supports ceramic media to improve heat exchange efficiency. Perimeter pre-cast columns support tilt-up pre-cast twin tee enclosure panels that begin at mid-tower height. The lower half of the tower is open. Roof mounted fans to draw air up through open lower portion. The roof structure is composite concrete constructed of pre-cast panels and a cast-in-place topping slab. The roof mounted fans and pre-cast concrete fan stack assemblies are supported by the interior columns and steel framing. The cooling towers were operational during our condition assessment, limiting our investigation to the pre-cast fan stack assemblies and the roof structure. The tilt-up pre-cast concrete twin tee enclosure panels are currently under investigation. This report will be available in early December.

The investigation was designed to find the mechanisms and magnitude of concrete deterioration in the roof deck and fan stack assemblies. A structural analysis, in-depth discussion of repair options and repair specifications will be completed in a second engineering phase.

Operational efficiencies, some interior framing structural members and the tower mechanical components related to operations and efficiency will not be addressed in our work.

Condition Assessment Measures

The condition survey was completed generally in accordance with ACI 201 "Condition Survey Guide". Specific parameters were targeted using the following measurements.

1. Chloride content samples were removed from the roof structure of all four cooling units.
2. Concrete core samples were removed from the roof structure of all four cooling towers for petrographic analysis.
3. Crack mapping of unit 1A was completed.
4. Delamination mapping of unit 1A was completed.
5. Concrete core samples were removed from the roof structure of Unit 1A and Unit 2B for compressive strength testing.
6. Chloride content samples were removed from two fan stacks each on unit 1A and 2B.
7. Concrete core samples were removed from Unit 2B fan stack number 04 and 07 for petrographic analysis.
8. Delamination mapping of two fan stacks each on unit 1A and 2B were completed.
9. A review of the structural drawings for each component studied was completed.

Chlorides, when present above the "threshold" limit at the depth of reinforcing steel, will initiate and accelerate corrosion. Chlorides may be cast into the original concrete mix or chlorides can diffuse into the concrete mass. The chloride sample plan was designed to determine these possibilities. Chloride limits in national codes vary widely. The American Concrete Institute Committee 318 allows for new construction, a maximum water-soluble chloride limit of 0.06 percent for pre-stressed concrete, 0.15% for reinforced concrete exposed to chlorides in service, and 0.30% for all other reinforced concrete construction. The 0.30% chloride is generally accepted as the "threshold" level for initiation of corrosion activity in carbon steel reinforced structure. For chlorides to be cast into the original concrete mix, the chloride content would generally be the same throughout the depth of the member. The roof deck chloride content results do not indicate chlorides were cast into the original topping concrete mix.

The chloride content analysis does indicate diffusion of chlorides into the concrete roof deck. This is determined by the diffusion gradient of the chloride content results. The roof decks were observed as wetting during cooler air temperatures. Steam exiting the fan stacks, condensed on the roof decks. The basin water contains 3800 ppm of chlorides. This was determined by the review of the water quality analysis. (See appendix 9 for water quality analysis). This condensation can provide the diffusion driver for chloride penetration. In all cases, the chlorides are well below the 0.30% limit for corrosion initiation. (See appendix 3 for chloride content results.) These results suggest that cracking occurred first, allowing only localized corrosion of the topping reinforcing steel.

Crack Mapping of Unit 1A Roof Deck

Significant cracking was observed on all unit roof decks. Two types of shrinkage cracking are present. Drying shrinkage cracking causing a "jointed" concrete topping is located at near equidistant spaces. A large number of plastic shrinkage cracks in the cast in place concrete were also observed. These plastic shrinkage cracks indicate difficult placement conditions or poor curing practice during original construction. A crack map of unit 1A was completed. (See appendix 4 for crack map). The drying shrinkage cracks are generally located over the joints of the pre-cast concrete roof panels.

Delamination Mapping of Unit 1A Roof Deck

The chain drag method of concrete sounding was used to map delamination in the cast in place roof topping. Unit 1A roof deck delamination is limited to approximately 5-8% of the roof deck area. (See appendix 5 for the delamination map). Approximately 30% delamination is considered significant in bridge deck repair. Approximately 75% of the eliminations are located near tooled joints in the cast in place topping. These joints are always located adjacent to or over a joint in the pre-cast concrete roof panels. The remaining delaminations are located in the "field" of the cast in place deck or along the cold joint of the roof deck and fan stack assembly. The "field" delaminations are generally small (1-4 square feet each) and are located at cracks formed by the joint of the pre-cast concrete roof panel. Concrete curling is probably the cause of the delaminations adjacent to the fan stack assemblies.

Compressive Strength of Roof Deck Concrete

A single core from unit 1A and 2B each were tested for compressive strength. The core samples were taken with a 4-inch diameter diamond tipped barrel. The cores were approximately 4 inches in length. The cores, taken in the cast in place concrete topping, generally de-bonded from the pre-cast concrete roof panels. Compressive strength of the core taken from unit 1A is 7600-psi. Compressive strength of the core taken from unit 2B is 5040-psi. This exceeds specifications found in "General Concrete Notes" of the original construction drawings. (See appendix 6 for compressive strength test results)

Petrographic Analysis of Roof Deck Core Samples

Petrographic analysis is used to find deterioration mechanisms due to poor concrete mix design, or aggregate types and gradation. It will also support findings in other tests and visual observations.

One core from each unit roof deck was analyzed. Construction Technology Laboratories, a division of The Portland Cement Association completed the petrography. (See appendix 7 for the full report).

According to findings in the CTL report, the roof deck concrete is generally good quality. The topping concrete is air-entrained. Deterioration mechanisms associated with poor air entraining were not observed visually. Carbonation depths are shallow, indicating again, quality concrete and little chance of accelerated deterioration. Quality aggregates were used with good gradation. Various crack types were observed, correlating with visual observations. Other unusual features were not found.

The core from Unit 1A Core #1 (sample 1AC4R1) has a hairline crack extending into the pre-cast roof panel. Repair of these cracks are necessary to protect the roof panels. The core from unit 1A was moderately bonded to the roof panel.

The core from Unit 2A (sample 2AC4R1) was not bonded between the pre-cast panel and the topping concrete. The core fracture plane, located in the pre-cast panel, passes through aggregate. This indicates quality concrete used for pre-casting. Impressions of the pre-stressing strand were found at the bottom of the sample. No corrosion staining was evident. We expect the pre-stressing strand is in original condition. Vertical cracks from 0.8 to 1.3 inches were found. These cracks, generally plastic shrinkage, are an access point for water, chlorides and other deterioration mechanisms.

The core from Unit 1B (sample 1BC4R1) had developed good bond between the pre-cast panel and the topping concrete. Vertical micro-cracks running to 1.5 inches are deep enough to reach the reinforcing are access points for deterioration mechanisms.

The core from Unit 2B (sample 2BC4R1) had developed bond between the pre-cast panel and the topping concrete. A void of 1.2-inch diameter was present, indicating localized

poor consolidation of the topping concrete. Our visual assessment did not find indications that this is widespread. Lower air content and slightly non-uniform air-void distribution should not cause accelerated deterioration.

Visual Assessment of the Fan Stacks

The fan stacks are constructed of conventionally reinforced pre-cast concrete. Visual observations indicate free lime leaching, modest concrete scaling, localized reinforcing steel corrosion and concrete spalls. Some cracks in the lower assemblies were observed and "oozing" water from the inside to outside. The fan stacks are not a critical structural element for extended service life of the towers. The free lime leaching and scaling can be contained by use of proper maintenance techniques. These two deterioration mechanisms appear to be very slow, given the current condition, and should not figure heavily into the new fan stack life expectancy. With appropriate repair and maintenance, all fan stacks should last the required 25-year service life. (See appendix 2 for photographs).

Results of Fan-Stack Chloride Content Samples

Chloride content samples were taken from 4 separate fan stack assemblies. Samples were removed from unit 1A, Fan Numbers 04 and 08. Samples were also removed from unit 2B, Fan Numbers 04 and 07. Chloride contents samples were taken at 1-inch depth to represent the level of conventional reinforcing steel in the lower stack assembly. Depths of 4 and 7-inches were also taken to determine if chlorides are cast into the mix or have diffused into the mass. Chlorides are not cast into the original mix. The chloride contents suggest that diffusion is occurring in the fan stack pre-cast assemblies. A diffusion gradient has been established. Chlorides at 1-inch depth of all fan stacks tested are higher than similar depths in the roof slab. Minimum concrete cover was measured at $\frac{3}{4}$ -inch. The maximum chloride content measured is 0.144%. (See Appendix 3 for chloride content results). All chlorides measured are below the 0.30% "threshold" level generally accepted for corrosion. However, localized corrosion of reinforcing steel is occurring. High chloride content water is escaping from the cold joint between the upper and lower fan stack assemblies contributing to the localized corrosion.

Delamination Mapping of Fan Stack Assemblies

Delamination mapping of fan stacks 1A04, 1A08, 2B04 and 2B07 reveal minor to modest deterioration. In the highway bridge industry, 30% concrete delamination in a bridge deck area is considered significant, requiring more than localized repair to extend its life for 20-30 additional years. The delamination and spalling in the stacks mapped, is centered almost exclusively on the lower stack assembly. Condensed cooling tower water is escaping at the cold joint between the lower and upper assembly. The area of the lower stack assembly is approximately 600 square feet. The delaminated area of the lower assembly for stacks 1A04, 1A08, 2B04, 2B07 is 10%, 5.5%, 28%, and 14% respectively. The higher delamination of 2B04 corresponds to the higher chloride content measured. We do not expect this to impose significant future deterioration. The upper assembly has

some very minor concrete spalling. (See appendix 8 for delamination maps of the lower fan stack assemblies).

Petrographic Analysis of Fan Stack Core Samples

A core sample from Unit 2B fan stack number 04, (sample 2BFS04) was observed petrographically. This core sample was previously drilled by other parties. The vertical hairline crack running the length of the core is a source of condensation escape, causing accelerated localized corrosion. Air entrainment is low, providing a source of trapped water leading to the free lime leaching. Calcium carbonate was observed in one crack. This is not a particular problem. Freeze and thaw cycles are minimal on this structure. Indications of freeze and thaw were not observed visually or found petrographically.

Petrographic analysis of the core from unit 2B fan stack number 07, (sample 2BFS07) was also completed. This core was also previously drilled by other parties. The hairline cracks observed are caused by the corrosion of embedded reinforcing. This is the beginning of a concrete spall. The entrained air is low by volume and non-uniform. This will trap water and cause lime leaching. The randomly oriented cracks are also sources of water entrapment. (See appendix 7 for petrography results).

Conclusions

Localized corrosion of embedded reinforcing steel is causing concrete deterioration in the cast in place roof topping and the pre-cast fan stack assemblies. Poor detailing of the concrete roof topping caused early age cracking, allowing for localized corrosion to begin. Condensation of the cooling tower water, escaping through "voids" in the pre-cast fan assemblies has accelerated the corrosion in these units. Remedial repairs and protective measures will significantly reduce or stop this corrosion. Proper repair methods and materials will extend the life of the roof deck and fan assemblies for a 25-year period.

Repair Concepts

The investigation to date has uncovered the sources of concrete deterioration in the roof deck and fan stack assemblies. The deterioration is confined to localized areas. Latent deficiencies in the concrete and structure were not found. Localized concrete repair, crack repair and protective systems will extend the life of these components the required 25 years.

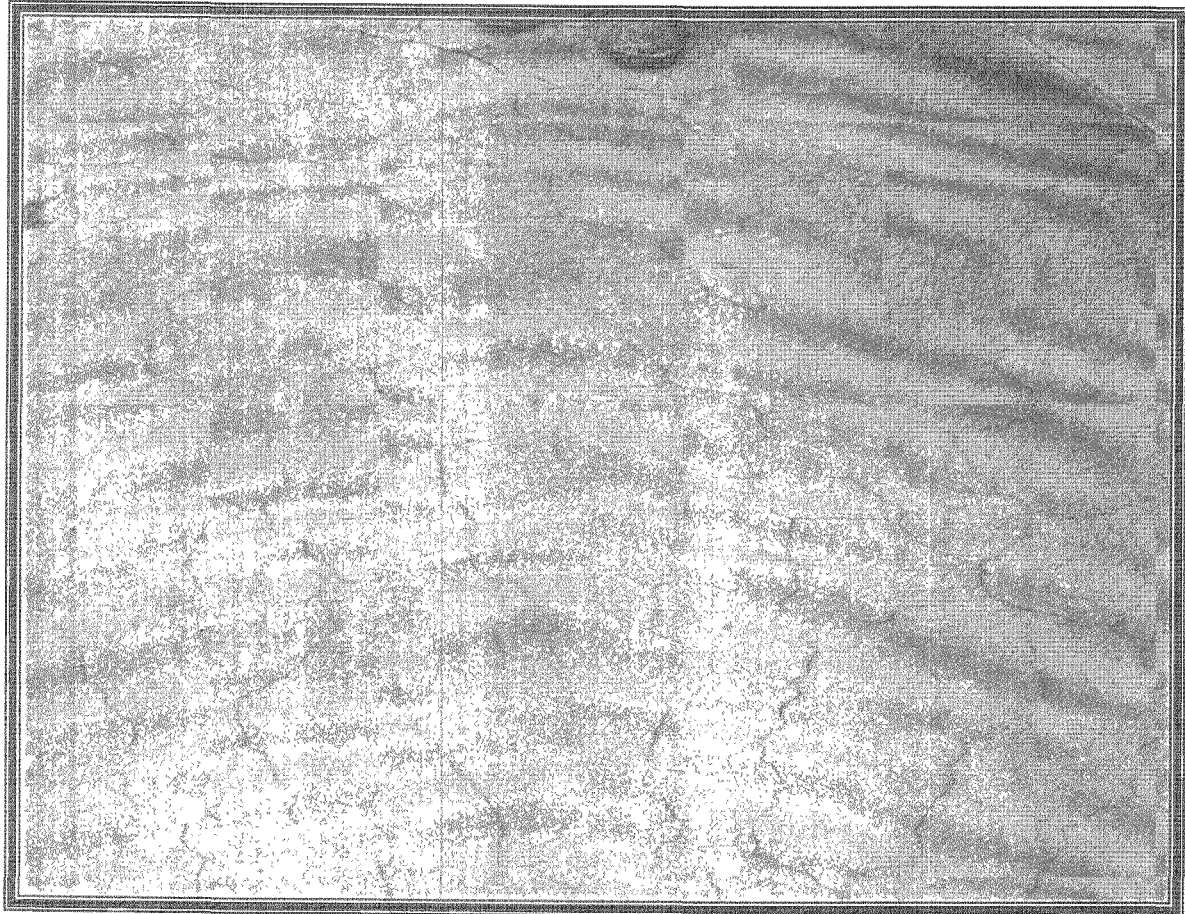
A structural analysis should be completed to verify that localized repair and patching will re-establish the original structural integrity. New loading conditions or code upgrading can also be addressed by the structural analysis.

We would be happy to begin work on phase 2, which will include the structural analysis, budgetary cost estimating and repair construction specifications at this time.

Photo #1

Roof Deck Plastic Shrinkage Cracking

Picture taken on roof of Unit 2B



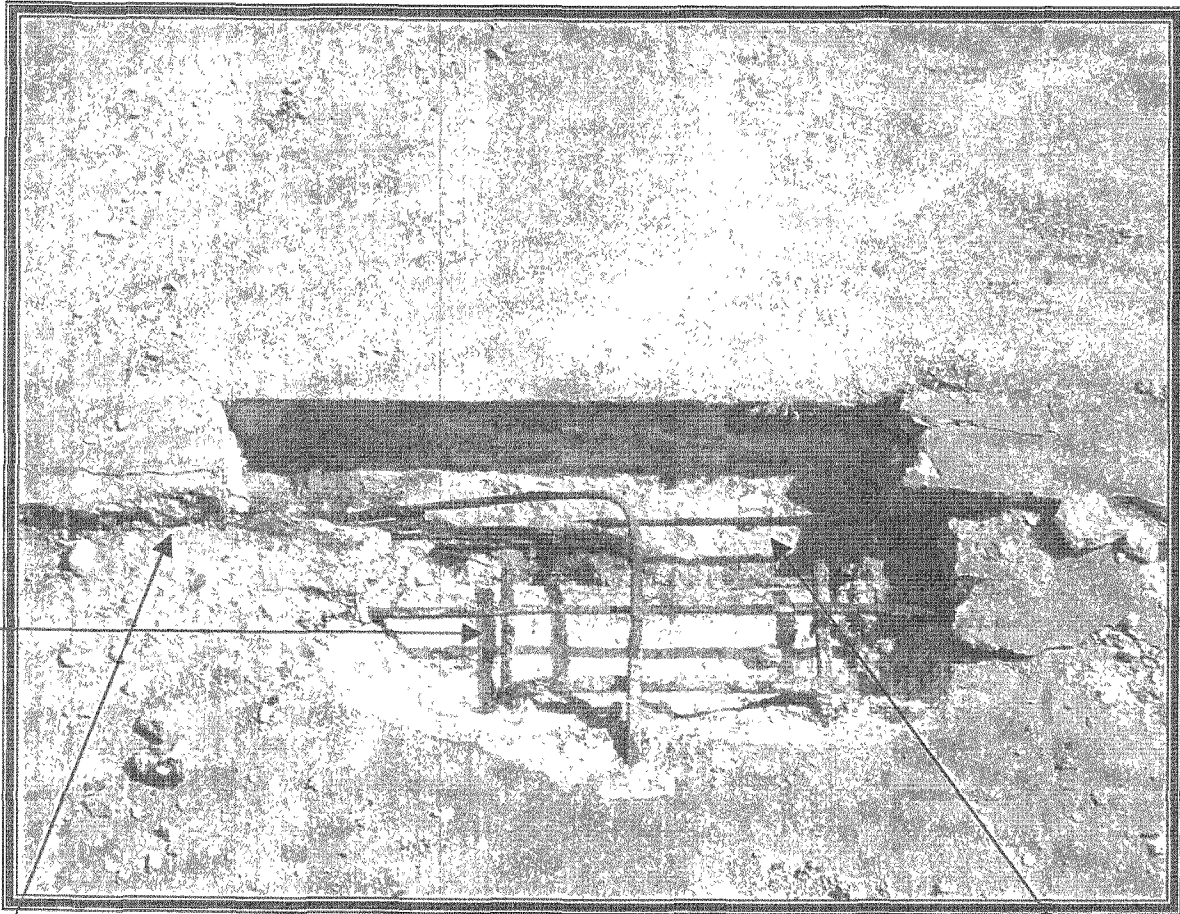
Notes

1. Large quantity of plastic shrinkage cracks in concrete topping should be repaired to eliminate deterioration mechanism.

Photo #2

Inspection Location #1

Cast in place concrete topping removed to top of pre-cast roof panel at Unit 1A



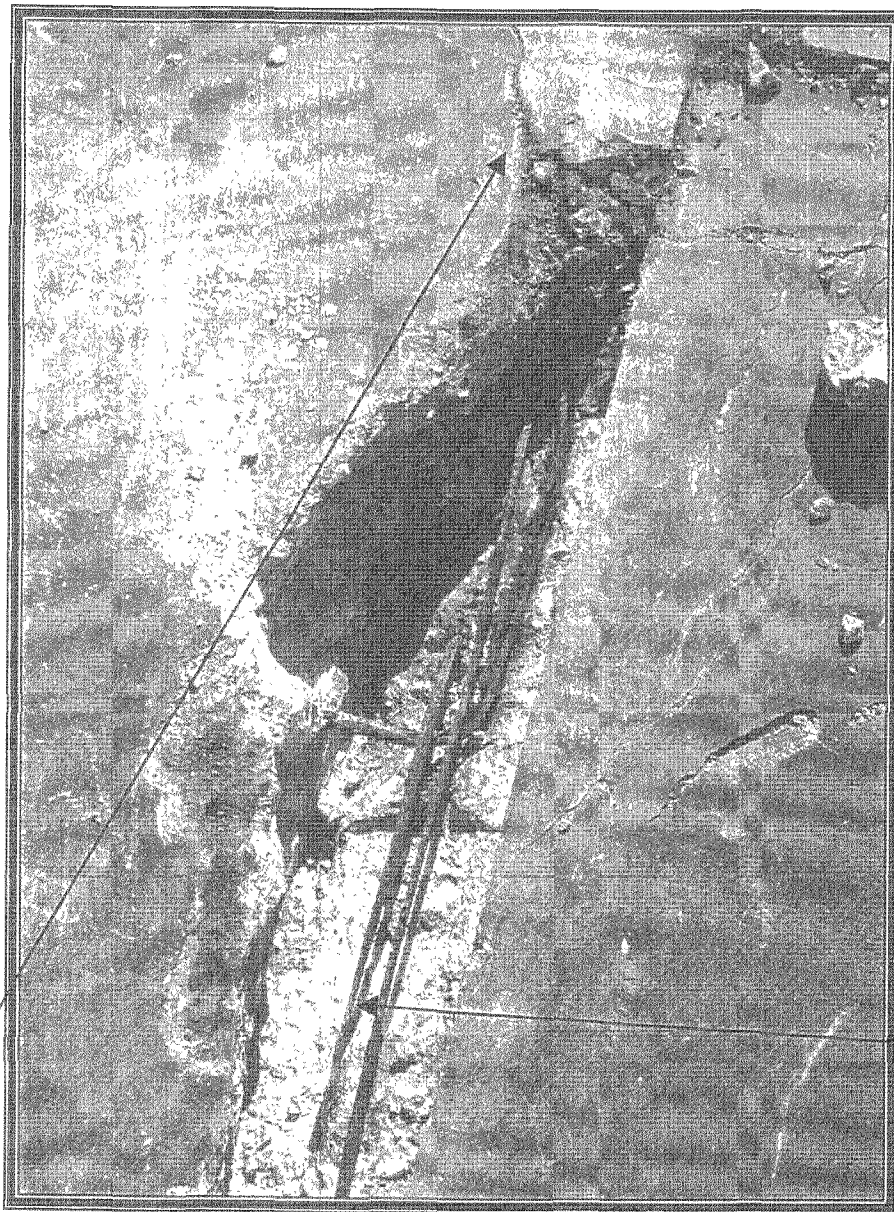
Notes

1. Complete corrosion of #3 bar running parallel to crack. Corrosion of bars and strand forming connection between roof panels and topping concrete.
2. Crack in cast in place concrete topping directly above joint in pre-cast roof panel.
3. Corrosion of re-bars stops within 8-12 inches of crack location.

Photo #3

Inspect Location #2

Cast in place topping removed to top of pre-cast roof panel on Unit 1A

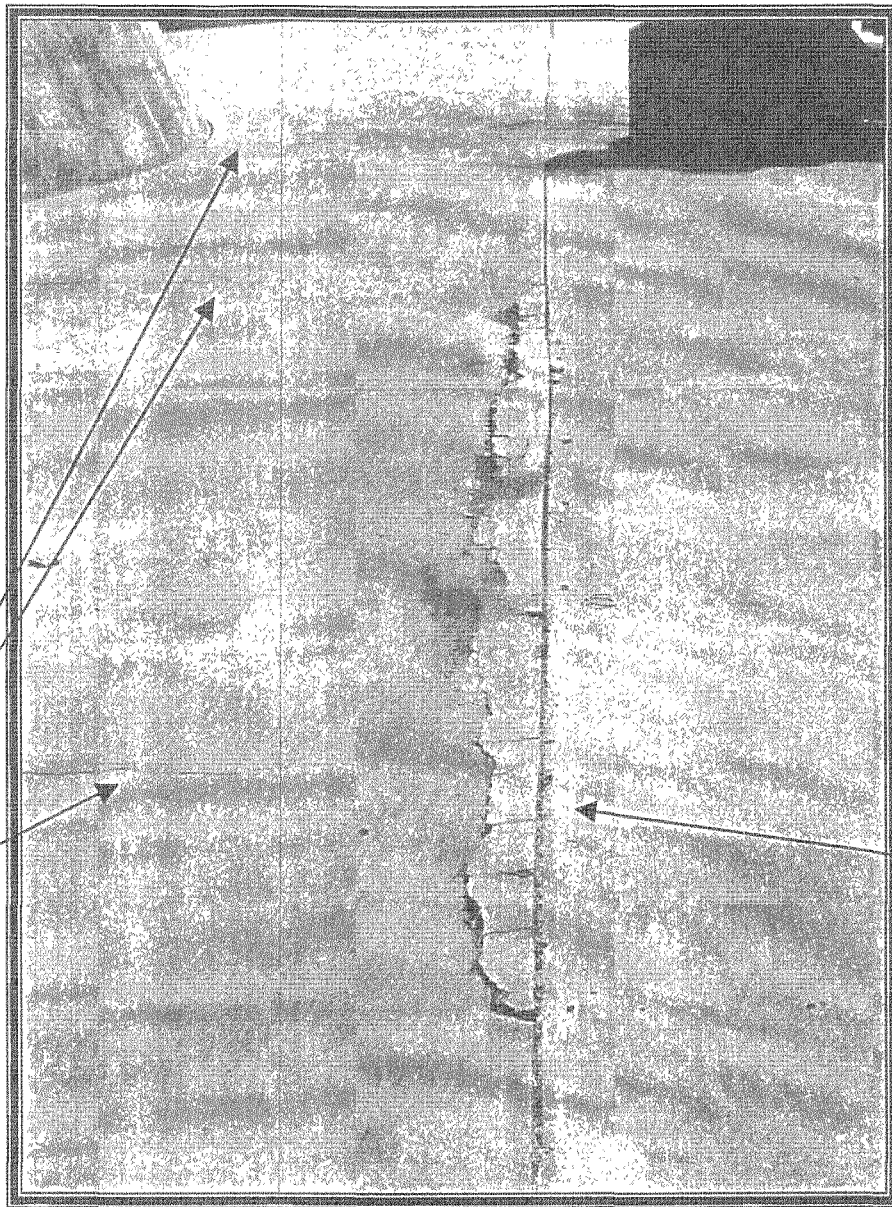


Notes

1. Crack over pre-cast roof panel joint, adjacent to but not at the sawed topping control joint.
2. Significant corrosion of re-bars forming the connection between topping and roof panels.

Photo #4

Cracks formed by joint at pre-cast roof panels

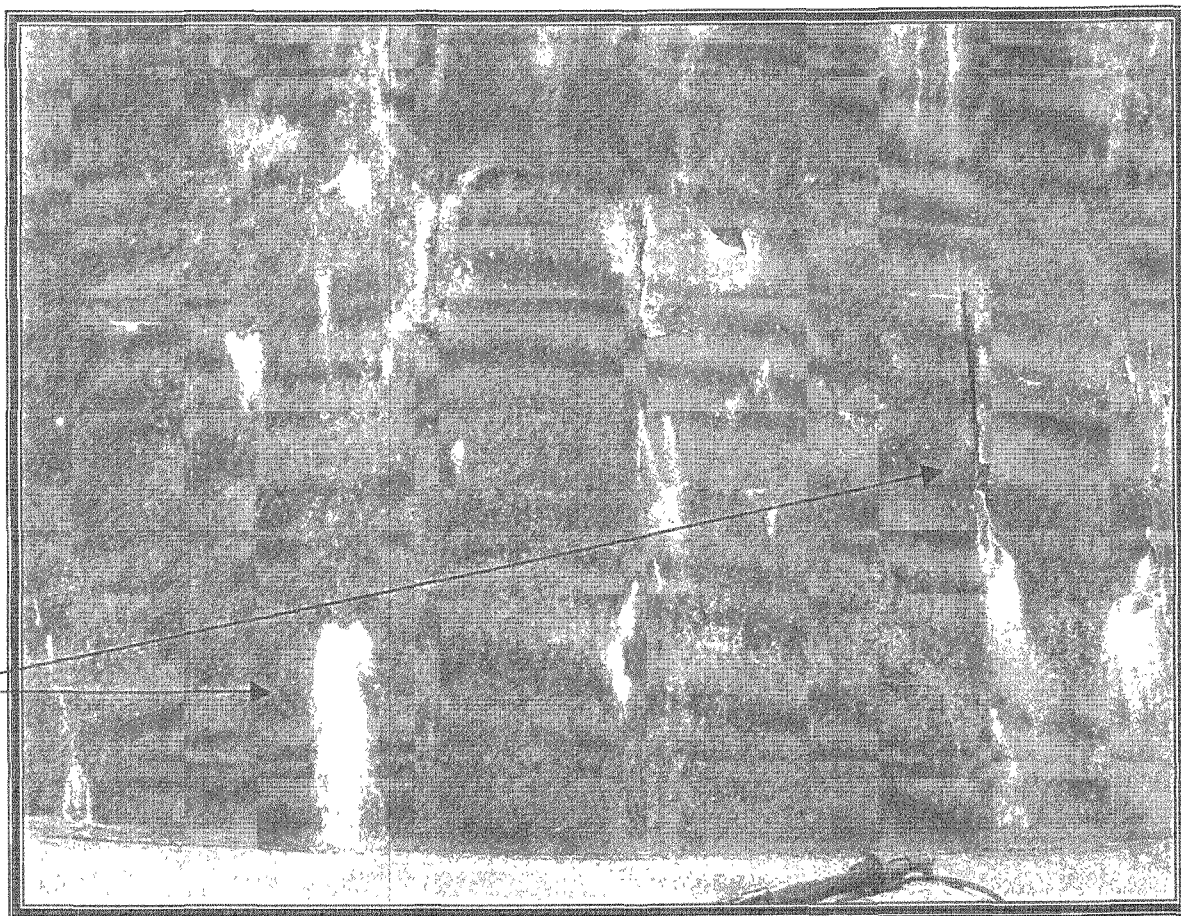


Notes

1. Sawed joint in concrete topping adjacent to crack. Crack directly above pre-cast panel joint.
2. Drying shrinkage cracks perpendicular to sawed joint directly above pre-cast roof panels.

Photo #5

Free Lime leaching at Fan Stack Assembly



Notes

1. Leaching at cracks, voids and spalled concrete locations.

Photo #6

Wet roof deck surface from steam condensation



FROM : WAL GOLDEN

FAX NO. : 303 278 2439

Oct. 10 2000 12:23PM P1



WYOMING ANALYTICAL LABORATORIES, INC.

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Fax: (303) 278-2439

October 10, 2000

Mr. Bruce Collins
Restruction Corp.
P.O. Box 343
Sedalia, CO 80135

RE: WAL # MM803

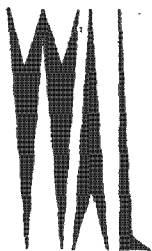
ANALYTICAL REPORT

WT %

<u>Sample ID</u>	<u>H2O Soluble Cl</u>
1A - Cl 1 1"	0.060 ✓
1A - Cl 1 4"	<0.002
1A - Cl 1 7"	<0.002
1A - Cl 2 1"	0.065 ✓
1A - Cl 2 4"	0.010
1A - Cl 2 7"	0.016
1A - Cl 3 1"	0.064 ✓
1A - Cl 3 4"	0.010
1A - Cl 3 7"	0.016
2A - Cl 1 1"	0.009 ✓
2A - Cl 1 4"	0.019
2A - Cl 1 7"	0.003
2A - Cl 2 1"	0.008 ✓
2A - Cl 2 4"	0.006
2A - Cl 2 7"	0.010
2A - Cl 3 1"	0.015 ✓
2A - Cl 3 4"	<0.002
2A - Cl 3 7"	0.004
1B - Cl 1 1"	0.078 ✓
1B - Cl 1 4"	0.006
1B - Cl 1 7"	<0.002
1B - Cl 2 1"	0.011 ✓
1B - Cl 2 4"	0.006
1B - Cl 2 7"	0.005
1B - Cl 3 1"	0.035 ✓
1B - Cl 3 4"	0.035
1B - Cl 3 7"	0.066

MEMBER
ACIL

IP12_011630



WYOMING ANALYTICAL LABORATORIES, INC.

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October 10, 2000

RE: WAL # MM803, Cont.

ANALYTICAL REPORT

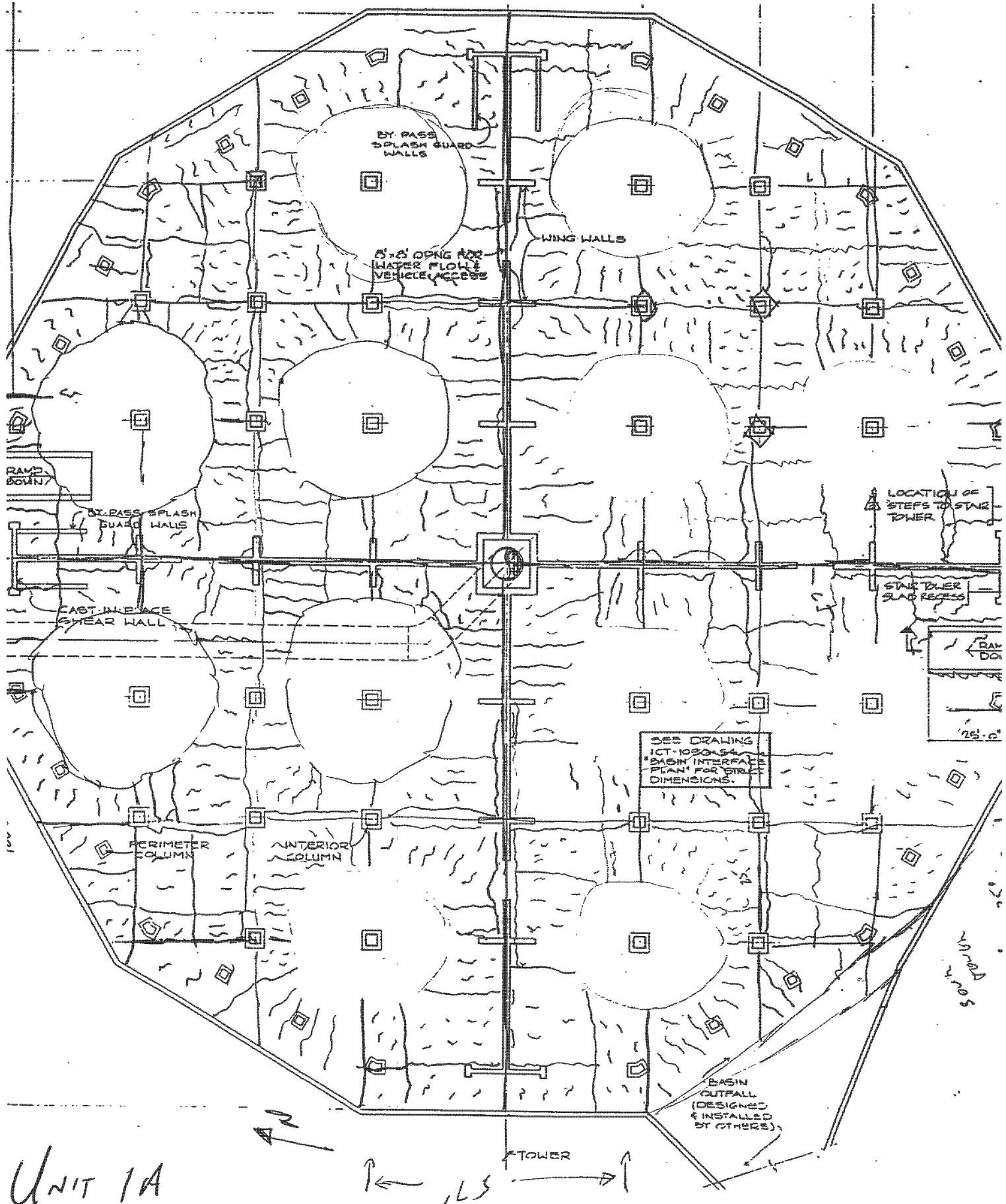
WT %

<u>Sample ID</u>	<u>H2O Soluble Cl</u>
2B - Cl 1 1"	0.019
2B - Cl 1 4"	< 0.002
2B - Cl 1 7"	< 0.002
2B - Cl 2 1"	0.025
2B - Cl 2 4"	< 0.002
2B - Cl 2 7"	< 0.002
2B - Cl 3 1"	0.042
2B - Cl 3 4"	0.019
2B - Cl 3 7"	< 0.002
1A FS Cl 1 1"	0.092
1A FS Cl 1 3"	0.048
1A FS Cl 2 1"	0.120
1A FS CL 2 3"	0.022
2B FS Cl 1 1"	0.094
2B FS Cl 1 4"	0.031
2B FS CL 1 7"	< 0.002
2B FS Cl 2 1"	0.144
2B FS Cl 2 2"	0.075
2B FS Cl 2 7"	< 0.002
2B FS Cl 3 1"	0.098
2B FS Cl 3 4"	< 0.002
2B FS Cl 4 1"	0.067
2B FS Cl 4 4"	0.020


Charles R. Wilson
Division Manager

MEMBER
ACIL

IP12_011631



UNIT 1A

CRACK MAP



PLAN VIEW $\frac{3}{32}'' = 1'-0''$
TOWER IS SHOWN

IP12_011632

OCT-02-2000 MON 02:15 PM AGEC

FAX NO. 8015666493

P. 01



Report of Compressive Strength

Test Methods: ASTM C 31, C 39, C 172, C 780, C 1019 and E 447

Applied Geotechnical
Engineering Consultants, Inc.

GENERAL CONTRACTOR:

PROJECT:

LOCATION:

PROJECT NO:

DATE CAST:

Restruccion Corp.
Bruce Collins
P.O. Box 343
Sedalia, CO
1000701

CONTACT:

Chris
972-1190
972-1377 fax

FIELD DATA (ASTM C 172)				DESIGN DATA (ASTM C 94)			
Placing Contractor: _____				Ready Mix Supplier: _____			
Time Cast: _____ am / pm				Mix Design Number: _____			
Slump (in) (C 143): _____				Specified Slump (in): _____			
Air Content (%) (C 231): _____				Specified Air Content (%): _____			
Mix Temp. (F) (C 106): _____				Specified Strength (f'): _____ psi @ 28 days			
Air Temp. (F): _____				Ticket No / Truck No.: _____			
Unit Wt. (pcf) (C 128): _____				Elapsed Batch Time (min): _____			
Material Type: Concrete <input checked="" type="checkbox"/> Grout <input type="checkbox"/> Mortar <input type="checkbox"/> Prisms <input type="checkbox"/> <u>C.C.</u>				Cement (lbs): _____ Fly ash (lbs): _____			
Sample Cast By: _____				Water (gal): _____ Added on Site (gal): _____			
Set Number: _____ of _____				Fine Aggregate (lbs): _____			
Samples Per Set: <u>2 cores</u>				Coarse Aggregate (lbs): _____			
Placement Location: _____				Admixtures: _____			
Sample Location: _____				Batch Size (yd): _____			
_____				Accum. No / Total (yd): _____ of _____			
_____				Sampled at: truck / pump			

Sample Identification Number	Test Age (Days)	Date of Test	Sample Size (in) ℓ	Cross Sectional Area (sq. in.)	Maximum Load (lbs)	Correction Factor	Compressive Strength (psi) (corrected)
10996-1	28	9/29	3.71 x 4.32	10.81	90275	0.91	8350 7600
10996-2	28	9/29	3.68 x 3.81	10.64	61650	0.87	5790 5040

Average Compressive Strength at 28 Days (psi): _____

Remarks: 10996-1 = 1 AC4RB
10996-2 = 2 BC4R2

Reviewed By: _____

600 West Sandy Parkway • Sandy, Utah 84070 • (801) 566-6399 • FAX (801) 566-6493
158 West 1600 South • St. George, Utah 84770 • (435) 673-6850 • FAX (435) 673-1044
White to AGEC; Yellow to AGEC Accounting; Pink to Recipient

IP12_011634



Applied Geotechnical
Engineering Consultants, Inc.

CLIENT: Restruction Corporation
Attn: Bruce Collins (303) 688-6733 fax
P.O. Box 343
Sedalia, CO 80135

PROJECT: Various testing
LOCATION:

PROJECT NO.: 1000701
PERMIT NO.:

DATE CAST: unknown

cc:

FIELD DATA (ASTM C 172)				DESIGN DATA (ASTM C 94)			
Placing Contractor:				Ready Mix Supplier:			
Time Cast:				Mix Design Number:			
Slump (in) (C 143):				Specified Slump (in):			
Air Content (%) (C 231):				Specified Air Content (%):			
Mix Temp. (°F) (C 1064):				Specified Strength: psi @ 28 days			
Air Temp. (°F):				Ticket No./Truck No:			
Unit Wt. (pcf) (C 138):				Elapsed Batch Time (min):			
Material Type: Concrete Core				Cement (lbs): Fly ash (lb)			
Sample Cast By:				Water (gal): Added on 5/1/00			
Set Number: 1 of 1				Fine Aggregate (lbs):			
Samples Per Set: 2				Coarse Aggregate (lbs):			
Placemant Location:				Admixtures:			
				Batch Size (yd³):			
				Accum. No./Total (yd³): of			
Sample Location:				Sampled at:			

Sample Identification Number	Test Age (Days)	Date of Test	Sample Size (in)	Cross Sectional Area (sq. in.)	Maximum Load (lbs.)	Correction Factor	Compressive Strength (psi)
10996-1		9/28	3.71x4.32	10.81	90,275	0.91	8,350
10996-2		9/28	3.68x3.81	10.64	61,650	0.87	5,750

Average Compressive Strength at 28 Days (psi)

Remarks: 10996-1 marked as 1AC4RB
10996-2 marked as 2BC4R2

Reviewed By:

IP12_011635

**UNREVIEWED
DRAFT****PETROGRAPHIC SERVICES REPORT**

CTL Project No.: 151631

Date: October 23, 2000

Re: Petrographic Examination of Concrete Core Samples from Cooling Tower Roof, IPP-Delta,
Utah

Six concrete core samples, labeled 1AC4RA, 2AC4R1 (Fig. 1), 1BC4R1, 2BC4R1 (Fig. 2), 2BFS04 and 2BFS07 (Fig.3) were received September 28, 2000 from Mr. Bruce Collins, Restruction Corporation, Colorado. The samples were reportedly taken from the above-referenced structure because of concern with cracking. Mr. Collins requested petrographic examination to evaluate concrete properties.

AND CORROSION OF REINFORCING

FINDINGS AND CONCLUSIONS

The results of the petrographic examination are summarized below; additional details of which are presented in the attached data sheets.

The mixture used to produce the concrete represented by the submitted core samples appears similar in quality and general characteristics between all of the six core samples examined. The main difference in the core samples is the presence or absence of vertical cracking and bond or not of the topping concrete, when present, to the prestress base concrete. The concrete mixture for the topping concrete was produced using a well-graded, 1/2 in. to 5/8 in. top size gravel coarse aggregate and a natural sand fine aggregate uniformly dispersed in an air-entrained portland cement paste.

Cracks are observed in all six cores ranging from minor localized microcracking to full topping thickness hairline cracks. The more significant of the observed cracks are the nearly vertical hairline cracks that extend the full topping thickness in Core Samples 1AC4RA, 2BACR1, 2BFS04, and full core length in Core Sample 2BFS04; these cracks typically pass through and

DRAFT

around aggregate particles. A hairline crack extends from the top surface in Core Sample 2BFS07 to a depth of 1.5 in. and passes through and around aggregate particles. The less significant of the observed cracks are the microcracks that penetrate just below the top surface or are randomly oriented in the body of the concrete. The general nature of the observed vertical cracks is consistent with cracks formed by shrinkage related to volume changes in concrete.

Core Samples 1AC4RA^{1?}, 2AC4R1, 1BC4R1, and 2BC4R1 exhibit topping concrete and prestress base concrete (Figs. 4 and 5). Topping thickness ranges from 3.4 in. to 4.2 in. Core Samples 2BFS04 and 2BFS07 are comprised of only one concrete placement (Fig. 6). Core Samples 1AC4RA^{1?} and 2AC4R1 were received with the topping concrete debonded from the prestress base concrete. The zone of separation (debonding) in Core Sample 1AC4RA^{1?} occurs mainly in the top portion of the base concrete indicating a good initial mechanical bond. The zone of separation in Core Sample 2AC4R1 occurs mainly at the interface. Core Samples 1BC4R1 and 2BC4R1 were received with the topping concrete bonded to the prestress base concrete.

The general quality of the concrete is fair to good, however, the condition of the concrete has been compromised because of the observed cracking.

METHODS OF TEST

Petrographic examination was performed in accordance with ASTM C 856-95, "Standard Practice for Petrographic Examination of Hardened Concrete." The core samples were cut longitudinally and one of the resulting surfaces of each was lapped and examined using a stereomicroscope at magnifications up to 45X. Surfaces of freshly broken concrete were also studied with the stereomicroscope. A small rectangular block was cut from the top surface of each core to a depth of approximately 1.8-in. placed on individual glass microscope slides with epoxy, and reduced to a thickness of approximately 20 micrometers (0.0008-in.). These thin sections were studied using a polarized-light microscope at magnifications up to 400X to determine aggregate and paste mineralogy and microstructure.

David B. Vollmer
Senior Petrographer
Petrographic Services

DBV

151631

Attachments

Use name

DRAFT

PETROGRAPHIC EXAMINATION OF HARDENED CONCRETE, ASTM C 856

CTL PROJECT NO.: 151631

DATE: October 23, 2000

CLIENT: Restruction Corporation

REPORTED PROBLEM: Cracking

STRUCTURE: Cooling Tower Roof

EXAMINED BY: D. B. Vollmer

LOCATION: IPP-Delta, Utah

Page 1 of 12

SAMPLE

Identification: Core Sample 1AC4RA *1?*

Dimensions: Diameter 3.7 in., length 6.0 in. to 6.5 in.; 3.5 in. of which is topping concrete.

Top Surface: Broom-finished surface is lightly eroded exposing fine aggregate particles.

Bottom Surface: Fracture surface passes through and around aggregate particles.

Cracks, Joints, Large Voids: Core was received separated at the topping/prestressed base concrete interface; the zone of separation occurs mainly in the topping concrete and locally at the interface. A nearly vertical hairline crack extends through the topping concrete and terminating in the base concrete at a maximum depth of 5.4 in. from core top surface; the cracks passes through and around aggregate particles. No joints or large voids observed.

Reinforcement: No reinforcement observed.

AGGREGATES

Coarse: Gravel composed mainly of various igneous rocks and limestone.

Fine: Natural sand composed mainly of quartz, feldspar, various igneous rocks and limestone.

Gradation & Top Size: Well graded to a top size of 1/2 in. to 5/8 in.

Page 2 of

Shape & Distribution: Coarse and fine aggregate particles are subangular to well rounded, elongated to spherical; aggregate distribution is uniform.

PASTE

Color: Medium gray.

Hardness: Moderately hard.

Luster: Dull to subvitreous.

Paste-Aggregate Bond: Moderately tight.

Air Content: Estimated at 5 to 7%, by volume of concrete; air entrained; air-void distribution is slightly nonuniform.

Depth of Carbonation: Locally to depths of 0.10 in. from core top surface.

Calcium Hydroxide*: 8 to 13%.

Unhydrated Portland Cement Clinker Particles (UPC's)*: 8 to 13%.

Pozzolans*: No pozzolans observed.

Secondary Deposits: Inwardly projecting ettringite crystals partially line some voids.

*Normal
Hydrated*

MICROCRACKING: A few randomly oriented microcracks are observed in core body.

ESTIMATED WATER-CEMENT RATIO: Moderate.

MISCELLANEOUS:

*percent by volume of paste

IP12_011640

DRAFT

PETROGRAPHIC EXAMINATION OF HARDENED CONCRETE, ASTM C 856

CTL PROJECT NO.: 151631

DATE: October 23, 2000

CLIENT: Restruction Corporation

REPORTED PROBLEM: Cracking

STRUCTURE: Cooling Tower Roof

EXAMINED BY: D. B. Vollmer

LOCATION: IPP-Delta, Utah

Page 3 of 12

SAMPLE

Identification: Core Sample 2AC4R1.

Dimensions: Diameter 3.7 in., length 6.0 in. to 6.6 in.; 4.0 in. of which is topping concrete

Top Surface: Broom-finished surface is lightly eroded exposing fine aggregate particles.

Bottom Surface: Fracture surface passes through and around aggregate particles.

Cracks, Joints, Large Voids: Core was received separated at the topping/prestressed concrete interface; the zone of separation occurs mainly at the interface. No macrocracks or large voids observed.

Reinforcement: Three impressions of what appear to be 0.125-in.-diameter smooth wires are exposed on core bottom surface; the impressions are free of corrosion product.

AGGREGATES

Coarse: Gravel composed mainly of various igneous rocks and limestone.

Fine: Natural sand composed mainly of quartz, feldspar, various igneous rocks and limestone.

Gradation & Top Size: Well graded to a top size of 1/2 in. to 5/8 in.

Shape & Distribution: Coarse and fine aggregate particles are subangular to well rounded, elongated to spherical; aggregate distribution is uniform.

PASTE

Color: Medium-dark gray.

Hardness: Moderately hard to hard.

Luster: Dull to subvitreous.

Paste-Aggregate Bond: Moderately tight.

Air Content: Estimated at 5 to 7%, by volume of concrete; air entrained; air-void distribution slightly nonuniform.

Depth of Carbonation: Locally to depths of 0.08 in. from core top surface.

Calcium Hydroxide*: 8 to 13%.

Unhydrated Portland Cement Clinker Particles (UPC's)*: 8 to 13%.

Pozzolans*: No pozzolans observed.

Secondary Deposits: No secondary deposits observed.

MICROCRACKING: A few nearly vertical microcracks extend from core top surface to depths of 0.8 in. to 1.3 in.; a few randomly oriented microcracks are observed in core body.

ESTIMATED WATER-CEMENT RATIO: Moderate.

MISCELLANEOUS:

*percent by volume of paste

DRAFT**PETROGRAPHIC EXAMINATION OF HARDENED CONCRETE, ASTM C 856***CTL PROJECT NO.:* 151631*DATE:* October 23, 2000*CLIENT:* Restruction Corporation*REPORTED PROBLEM:* Cracking*STRUCTURE:* Cooling Tower Roof*EXAMINED BY:* D. B. Vollmer*LOCATION:* IPP-Delta, Utah

Page 5 of 12

SAMPLE*Identification:* Core Sample 1BC4R1.*Dimensions:* Diameter 3.7 in.; length 4.4 in. to 5.1 in.; 3.4 in. of which is topping concrete.*Top Surface:* Broom-finished surface is lightly eroded exposing fine aggregate particles.*Bottom Surface:* Fracture surface passes through and around aggregate particles.*Cracks, Joints, Large Voids:* Core was received with the topping and prestressed concrete bonded.*No macrocracks, joints or large voids observed.**Reinforcement:* No reinforcement observed.**AGGREGATES***Coarse:* Gravel composed mainly of various igneous rocks and limestone.*Fine:* Natural sand composed mainly of quartz, feldspar, various igneous rocks and limestone.*Gradation & Top Size:* Well graded to a top size of 1/2 in. to 5/8 in.*Shape & Distribution:* Coarse and fine aggregate particles are subangular to well rounded, elongated to spherical; aggregate distribution is uniform.**PASTE***Color:* Medium-light gray.**IP12_011643**

Page 6 of 12

Hardness: Moderately hard.

Luster: Dull to subvitreous.

Paste-Aggregate Bond: Moderately weak to moderately tight.

Air Content: Estimated at 4 to 6%, by volume of concrete; air entrained; air-void distribution slightly nonuniform.

Depth of Carbonation: Locally to depths of 0.04 in. from core top surface.

Calcium Hydroxide*: 5 to 10%.

Unhydrated Portland Cement Clinker Particles (UPC's)*: 8 to 13%.

Pozzolans*: No pozzolans observed.

Secondary Deposits: No secondary deposits observed.

MICROCRACKING: A nearly vertical microcracks is observed extending from core top surface to a depth of 1.5 in.; randomly oriented microcracks are locally abundant in core body.

ESTIMATED WATER-CEMENT RATIO: Moderate.

MISCELLANEOUS:

*percent by volume of paste

IP12_011644

DRAFT

PETROGRAPHIC EXAMINATION OF HARDENED CONCRETE, ASTM C 856

CTL PROJECT NO.: 151631

DATE: October 23, 2000

CLIENT: Restruction Corporation

REPORTED PROBLEM: Cracking

STRUCTURE: Cooling Tower Roof

EXAMINED BY: D. B. Vollmer

LOCATION: IPP-Delta, Utah

Page 7 of 12

SAMPLE

Identification: Core Sample 2BC4R1.

Dimensions: Diameter 3.7 in.; length 5.7 in. to 6.2 in.; 4.2 in. of which is topping concrete.

Top Surface: Broom-finished surface is lightly eroded exposing fine aggregate particles.

Bottom Surface: Fracture surface passes through and around aggregate particles.

Cracks, Joints, Large Voids: Core was received with the topping and prestressed concrete bonded. A single nearly vertical hairline crack extends from core top surface through the large entrapped void to a depth of 4.6 in. from core top surface, which is just below the topping/prestress concrete interface; this microcrack passes around aggregate particles. No joints observed. A single 1.2-in-diameter entrapped void is observed at a depth of approximately 0.5 in. from core top surface.

Reinforcement: No reinforcement observed.

AGGREGATES

Coarse: Gravel composed mainly of various igneous rocks and limestone.

Fine: Natural sand composed mainly of quartz, feldspar, various igneous rocks and limestone.

Gradation & Top Size: Well graded to a top size of 1/2 in. to 5/8 in.

Page 8 of 12

Shape & Distribution: Coarse and fine aggregate particles are subangular to well rounded, elongated to spherical; aggregate distribution is uniform.

PASTE

Color: Medium gray.

Hardness: Moderately hard.

Luster: Dull to subvitreous.

Paste-Aggregate Bond: Moderately weak to moderately tight.

Air Content: Estimated at 4 to 6% by volume of concrete; air entrained; air-void distribution is slightly nonuniform.

Depth of Carbonation: Locally to depths of 0.09 in. from core top surface.

Calcium Hydroxide*: 8 to 13%.

Unhydrated Portland Cement Clinker Particles (UPC's)*: 8 to 13%.

Pozzolans*: No pozzolans observed.

Secondary Deposits: No secondary deposits observed.

MICROCRACKING: A single subparallel microcrack is observed just below core top surface, 0.15-in. depth, and passes around aggregate particles. Randomly oriented microcracks are locally abundant in core body.

ESTIMATED WATER-CEMENT RATIO: Moderate.

MISCELLANEOUS:

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PETROGRAPHIC EXAMINATION OF HARDENED CONCRETE, ASTM C 856

CTL PROJECT NO.: 151631

DATE: October 23, 2000

CLIENT: Restruction Corporation

REPORTED PROBLEM: Cracking

STRUCTURE: Cooling Tower Roof

EXAMINED BY: D. B. Vollmer

LOCATION: IPP-Delta, Utah

Page 9 of 12

SAMPLE

Identification: Core Sample 2BFS04.

Dimensions: Diameter 3.7 in.; length 3.8 in. to 4.8 in.

Top Surface: Flat smooth surface.

Bottom Surface: Fracture surface passes through and around aggregate particles.

Cracks, Joints, Large Voids: A nearly vertical hairline crack extends the length of the core passing through and around aggregate particles. No joints or large voids observed.

Reinforcement: No reinforcement observed.

AGGREGATES

Coarse: Gravel composed mainly of various igneous rocks and limestone.

Fine: Natural sand composed mainly of quartz, feldspar, various igneous rocks and limestone.

Gradation & Top Size: Well graded to a top size of 1/2 in. to 5/8 in.

Shape & Distribution: Coarse and fine aggregate particles are subangular to well rounded, elongated to spherical; aggregate distribution is uniform.

PASTE

Color: Medium gray.

Hardness: Moderately hard.

Luster: Dull to subvitreous.

Paste-Aggregate Bond: Moderately tight.

Air Content: Estimated at 1.5 to 3.5%, by volume of concrete; air entrained; air-void distribution slightly nonuniform.

Depth of Carbonation: Locally to depths of 0.13 in. from core top surface.

Calcium Hydroxide*: 10 to 15%.

Unhydrated Portland Cement Clinker Particles (UPC's)*: 5 to 10%.

Pozzolans*: No pozzolans observed.

Secondary Deposits: Inwardly projecting ettringite crystals line some voids. Calcium carbonate is observed lining the interior surfaces of the vertical crack.

MICROCRACKING: A few randomly oriented microcracks are observed in core body.

ESTIMATED WATER-CEMENT RATIO: Moderate.

MISCELLANEOUS:

*percent by volume of paste

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PETROGRAPHIC EXAMINATION OF HARDENED CONCRETE, ASTM C 856

CTL PROJECT NO.: 151631

DATE: October 23, 2000

CLIENT: Restruction Corporation

REPORTED PROBLEM: Cracking

STRUCTURE: Cooling Tower Roof

EXAMINED BY: D. B. Vollmer

LOCATION: IPP-Delta, Utah

Page 11 of 12

SAMPLE

Identification: Core Sample 2BFS07.

Dimensions: Diameter 3.7 in.; length 4.1 in. to 5.0 in.

Top Surface: Flat smooth surface.

Bottom Surface: Fracture surface passes through and around aggregate particles.

Cracks, Joints, Large Voids: A few hairline cracks extend from core top surface to depths of 1.5 in. passing through and around aggregate particles.

Reinforcement: A No 3 rebar has 1.4 in. of concrete cover from core top surface; a No. 4 rebar 1.7 in. of concrete cover from core top surface. Rebars are oriented parallel to each other and exhibit patches of surficial corrosion.

AGGREGATES

Coarse: Gravel composed mainly of various igneous rocks and limestone.

Fine: Natural sand composed mainly of quartz, feldspar, various igneous rocks and limestone.

Gradation & Top Size: Well graded to a top size of 1/2 in. to 5/8 in.

Shape & Distribution: Coarse and fine aggregate particles are subangular to well rounded, elongated to spherical; aggregate distribution is uniform.

PASTE

Color: Medium gray.

Hardness: Moderately hard.

Luster: Dull to subvitreous.

Paste-Aggregate Bond: Moderately tight.

Air Content: Estimated at 2 to 4%, by volume of concrete; air entrained; air-void distribution is nonuniform; entrained air-void clusters are abundant.

Depth of Carbonation: Locally to depths of 0.13 in. from core top surface.

Calcium Hydroxide*: 8 to 13%.

Unhydrated Portland Cement Clinker Particles (UPC's)*: 5 to 10%.

Pozzolans*: No pozzolans observed.

Secondary Deposits: Inwardly projecting ettringite crystals line some voids.

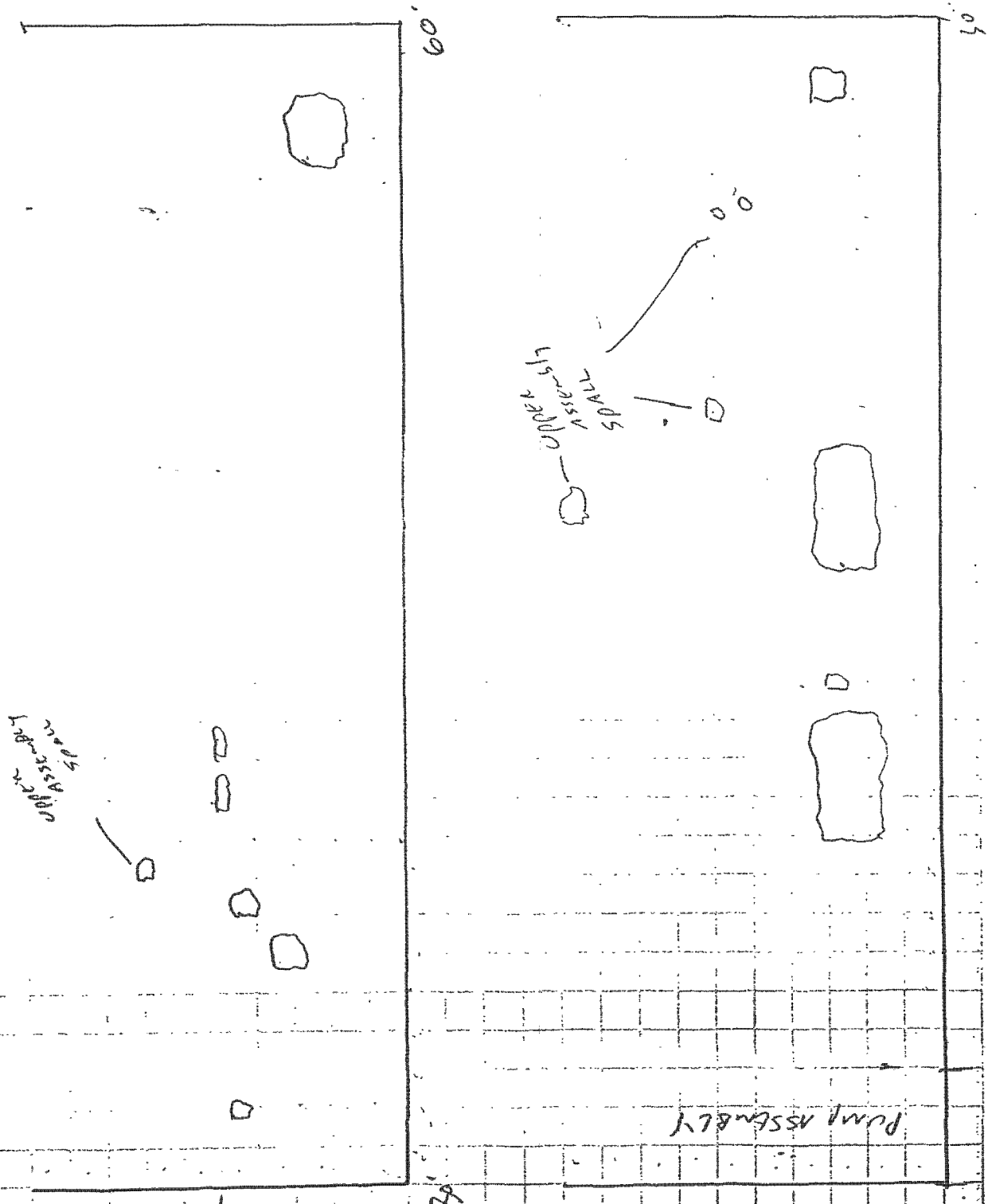
MICROCRACKING: Patterned microcracks on core top surface extend nearly vertical to depths of 0.1 in.; randomly oriented microcracks are locally abundant in core body.

ESTIMATED WATER-CEMENT RATIO: Moderate.

MISCELLANEOUS:

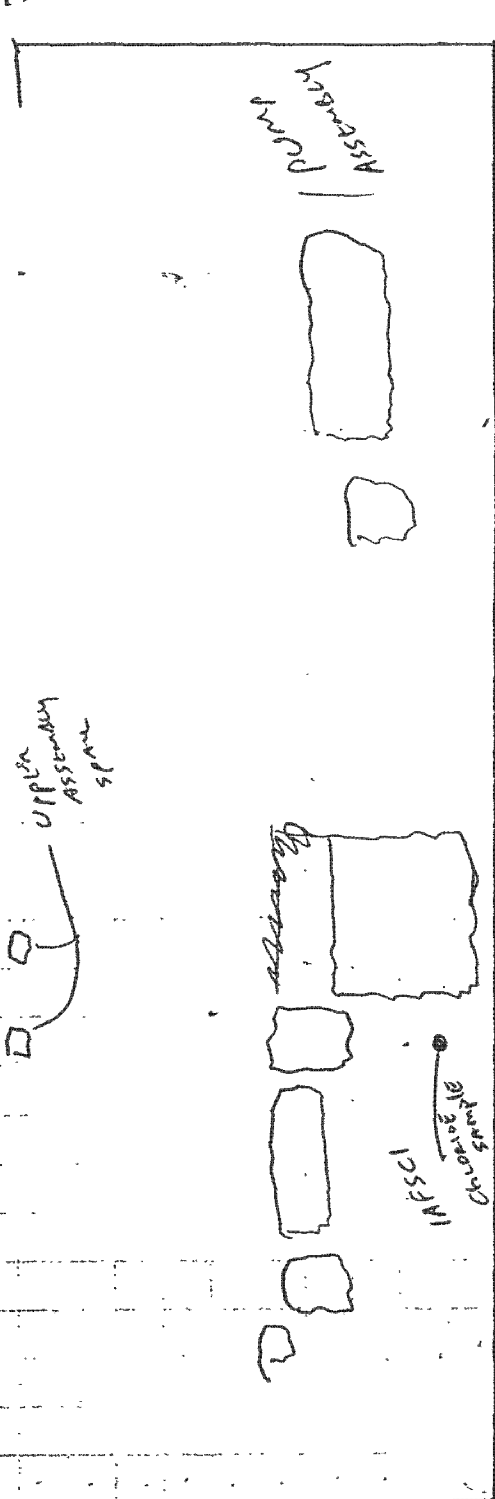
*percent by volume of paste

FAN STACK DELIMINATION SURVEY # 1A 04



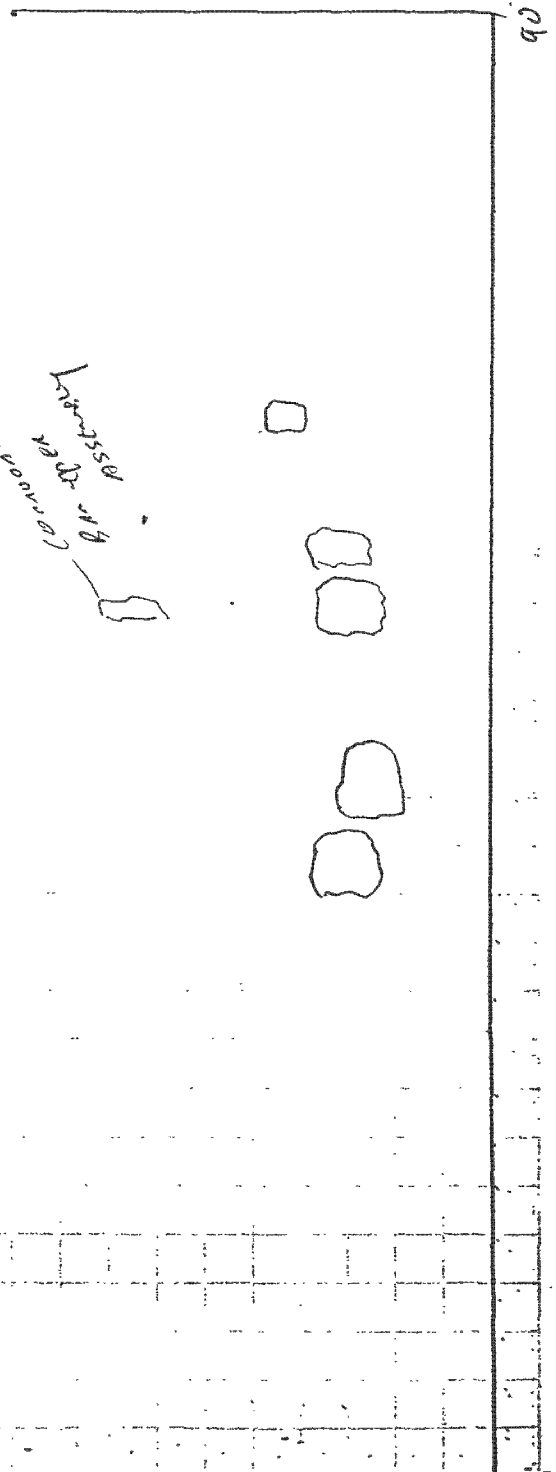
FAN STACK DELIMINATION SURVEY 1A04

TOP OF FAN STACK
ASSEMBLY



120'

LOWER ASSEMBLY

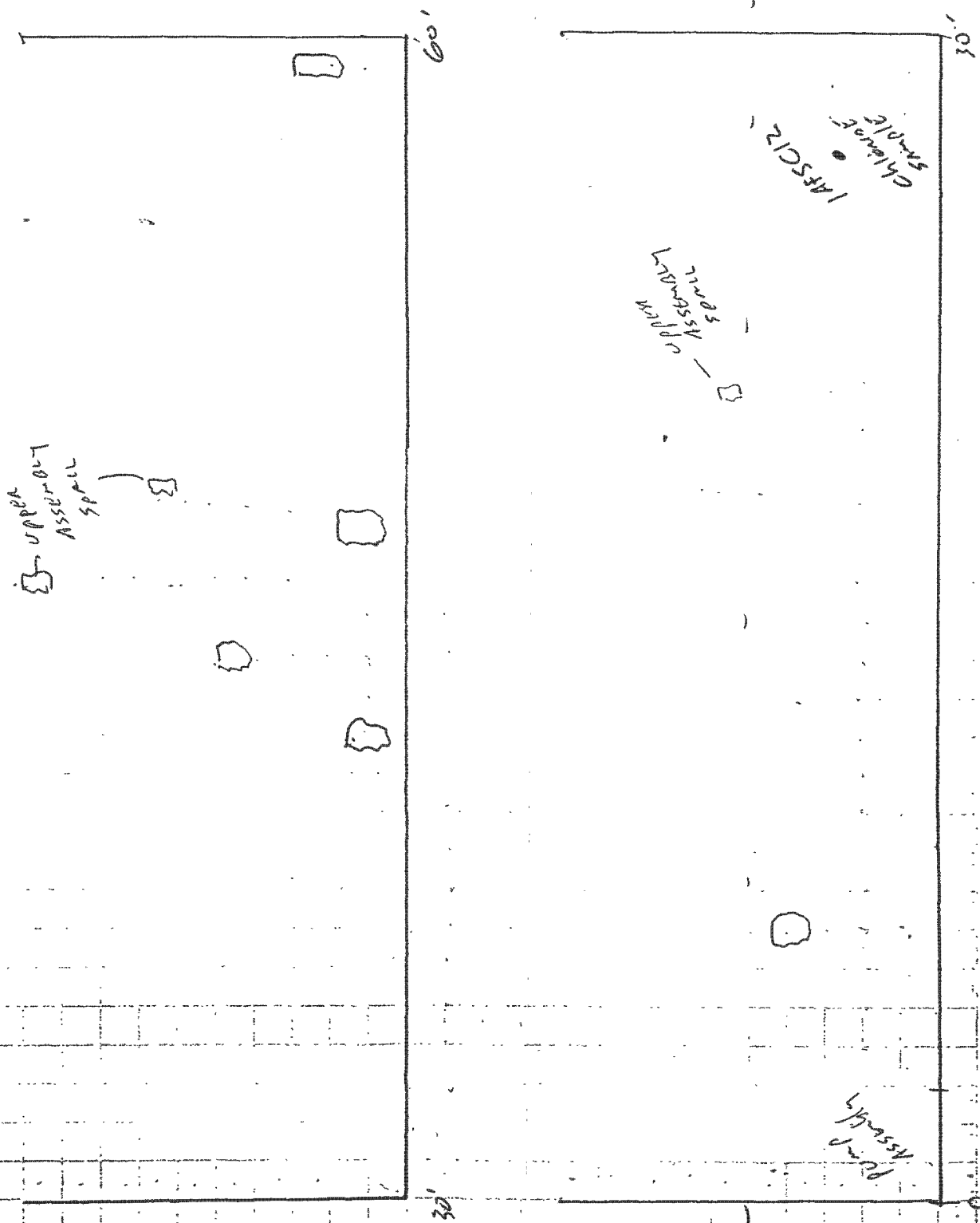


90'

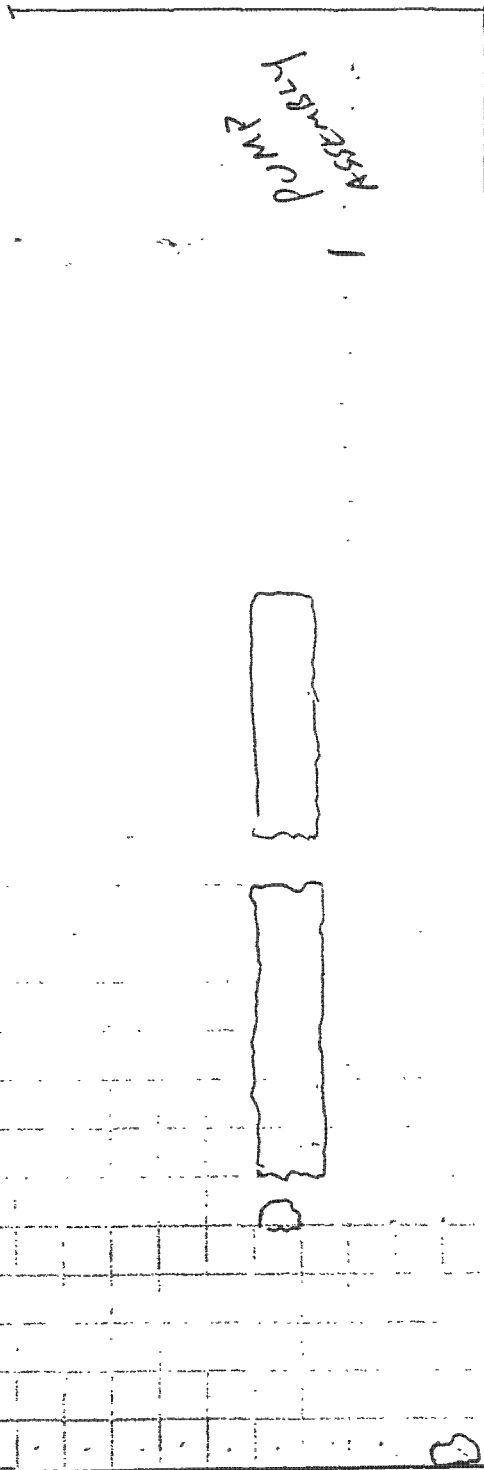
FAN STACK DELIMINATION SURVEY

1A08 PUMP ASSEMBLY FACING OPPOSITE OF 1A04

1200
1410
1510

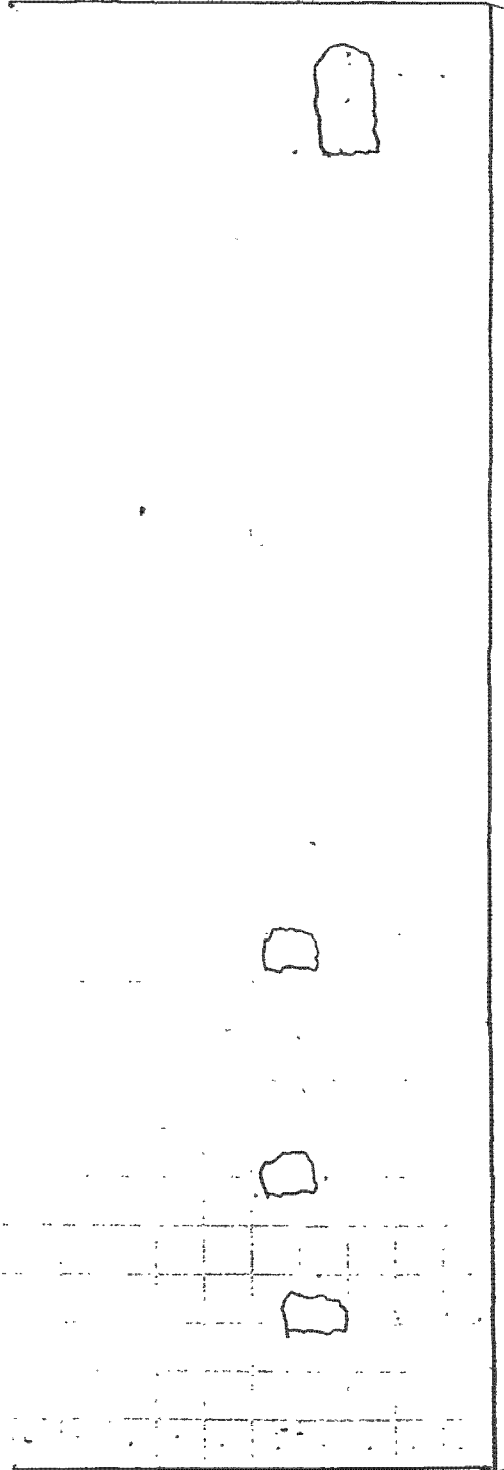


FAN STACK DELAMINATION SURVEY
1A08



021

06



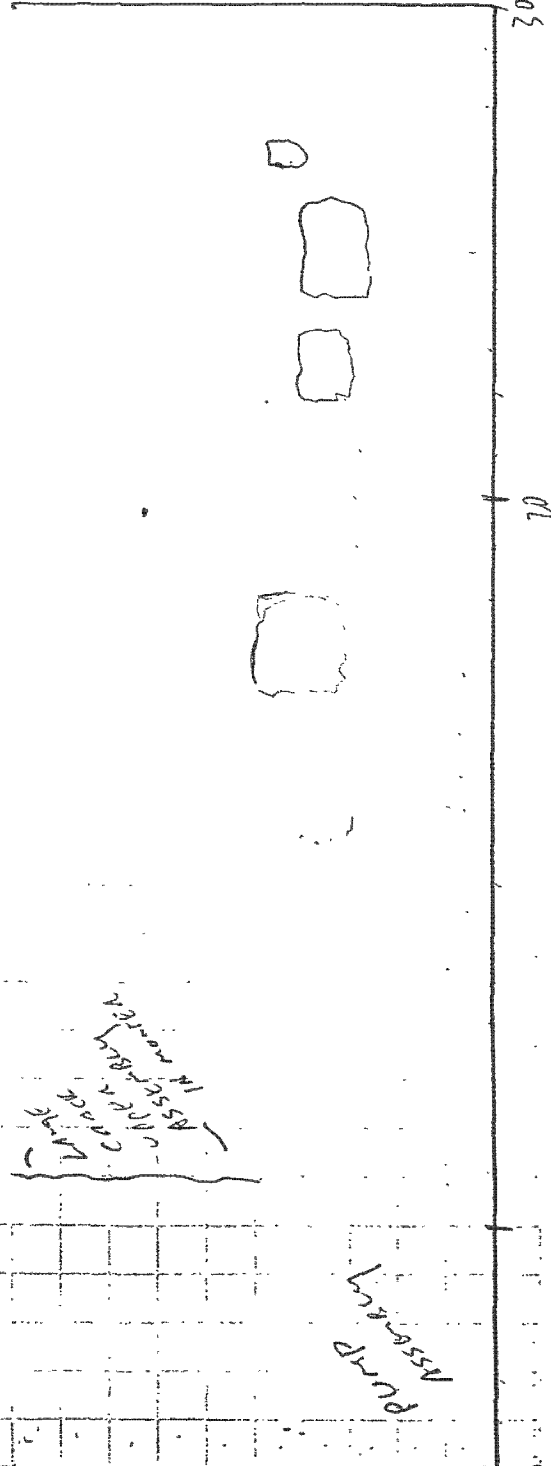
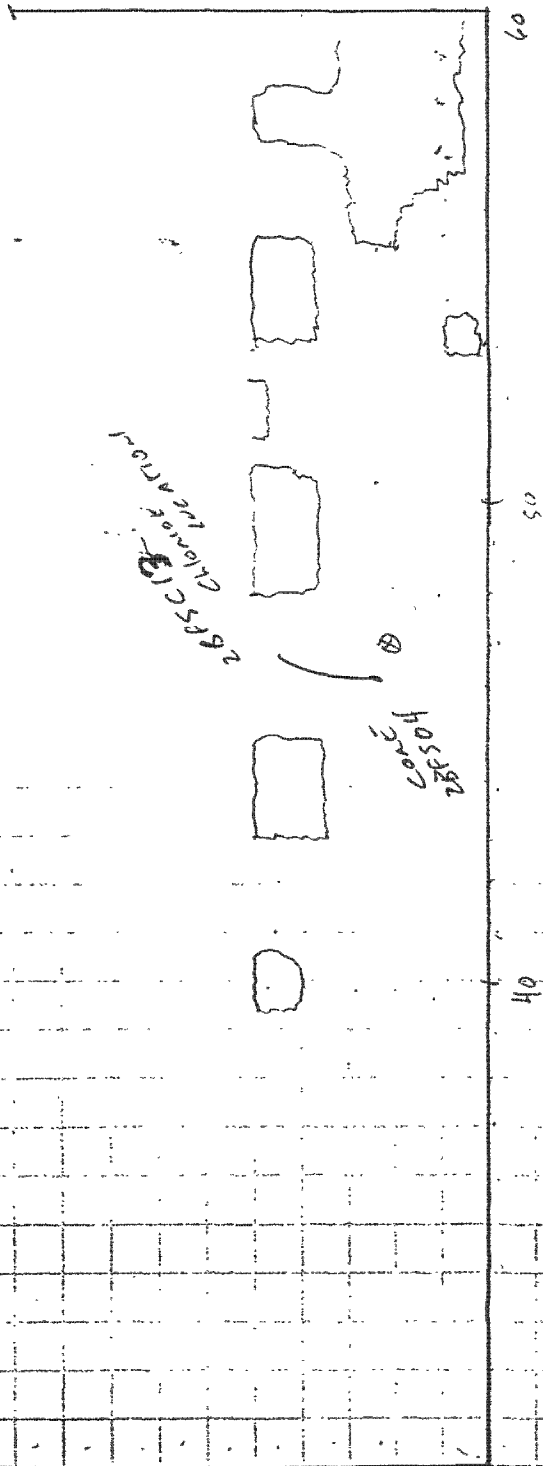
06

06

FAN STACK DELIMINATION SURVEY

2BFS 04 PUMP ASSEMBLY SAME SIDE AS 2BFS07

21
11
12



FAN STACK DELAMINATION SURVEY 2BF504

FS
TOP OF ASSEMBLY

UPPER ASSEMBLY
SPACE

PREVIOUS
CORE

OLD
DELAMINATIONS

UPPER
ASSEMBLY
SPACE

UPPER
ASSEMBLY
SPACE

OLD
DELAMINATIONS

FAN STACK DELAMINATION SURVEY FAN ZBF507

42
3
12.6

STEEL COVER
PREVIOUS CONE
15 1/2" - 1"

PARASOL
CONE

2B PSC12
CHANGING

SCALE: 1 BOX = 1'

MS. 3.5 PPM

TOP OF UPPER FS
ASSEMBLY

PUMP
ELECTRIC
ASSEMBLY

FAN BASE

18

27



NALCO CHEMICAL COMPANY

ONE NALCO CENTER • NAPERVILLE, ILLINOIS 60563 - 1198

Analytical Report

Intermountain Power
Delta UT
Sample Marked: #1 Unit Main Condenser Outlet

Sample Number: NW0018323
Date Sampled: 21-Jun-2000
Date Received: 22-Jun-2000
Date Completed: 29-Jun-2000

Water Analysis

ICP - Inductively Coupled Plasma	Filtered	Total	
Aluminum (Al)	< 1.0	< 1.0	ppm
Barium (Ba)	< 1.0	< 1.0	ppm
Boron (B)	2.0	2.0	ppm
Cadmium (Cd)	< 0.10	< 0.10	ppm
Calcium (CaCO3)	790	790	ppm
Chromium (Cr)	< 0.10	< 0.10	ppm
Copper (Cu)	< 0.10	< 0.10	ppm
Iron (Fe)	1.2	1.9	ppm
Lead (Pb)	< 1.0	< 1.0	ppm
Lithium (Li)	0.54	0.56	ppm
Magnesium (CaCO3)	1400	1400	ppm
Manganese (Mn)	< 0.10	< 0.10	ppm
Molybdenum (Mo)	< 1.0	< 1.0	ppm
Nickel (Ni)	< 1.0	< 1.0	ppm
Phosphorus (PO4)	< 3.1	< 3.1	ppm
Potassium (K)	64	64	ppm
Silica (SiO2)	53	53	ppm
Sodium (CaCO3)	4700	4700	ppm
Strontium (Sr)	2.3	2.3	ppm
Vanadium (V)	< 0.10	< 0.10	ppm
Zinc (Zn)	< 0.10	< 0.10	ppm
IC - Anions by IC			
Bromide (Br)		< 2.9	ppm
Nitrite (NO2)		< 2.9	ppm
Chloride (CaCO3)		3800	ppm
Nitrate (CaCO3)		13	ppm
Sulfate (CaCO3)		3200	ppm
ALK - Alkalinity			
Bicarbonate (CaCO3)		23	ppm
Methyl Orange (CaCO3)		23	ppm
Phenolphthalein (CaCO3)		< 1	ppm
Others			
Phosphate (PO4) - Polyphosphate		0.20	ppm
Fluoride (F)		2.0	ppm
Phosphate (PO4) - Total Ortho & Poly		0.80	ppm





NALCO CHEMICAL COMPANY
ONE NALCO CENTER • NAPERVILLE, ILLINOIS 60563 - 1198

Analytical Report

Intermountain Power

Delta UT

Sample Marked: #1 Unit Main Condenser Outlet

Sample Number:

NW0018323

Date Sampled:

21-Jun-2000

Date Received:

22-Jun-2000

Date Completed:

29-Jun-2000

Water Analysis

Others

Phosphate (PO₄) - Orthophosphate

0.60 ppm

Phosphate (PO₄) - Organic

< 0.2 ppm

Phosphate (PO₄) - Total

0.90 ppm

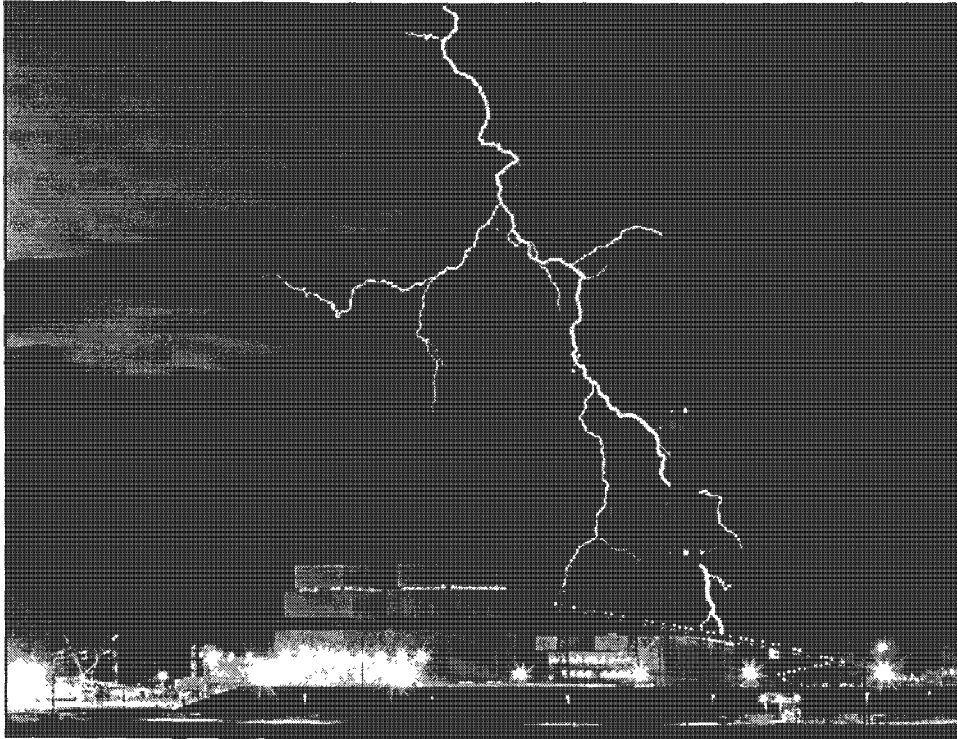
pH

7.2 pH Units

Conductivity

13000 mmhos/cm





Babcock & Wilcox

a McDermott company

Suite 410
7401 West Mansfield Avenue
Lakewood, CO 80235
(303) 988-8203

March 20, 1991

Intermountain Power Service Corporation
Route 1, Box 864
Delta, Utah 84624

Attn: Mr. Aaron Nissen
Plant Engineer

Re: Performance Test Report
Unit No. 2
B&W Contract RB-615

Dear Aaron:

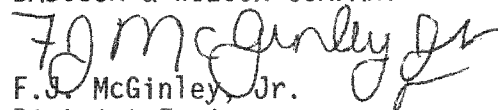
Enclosed for your files are four (4) copies of the test report for the performance tests conducted on Unit #2, RB-615, during the month of November, 1990.

The results are consistent with previous tests conducted on the two units. The efficiency has improved 0.3% with the new air heater surface. The results would indicate that additional cooling air to the idle burners does not significantly impact unit performance. Testing was not conducted with top burners out of service. A proposal to conduct cooling air tests with various mills out of service can be forwarded to your attention should you so desire. Please note that a 15% reduction in our normal per diem rates would apply during the months of June and July.

Should you have any questions or comments, please do not hesitate to contact me at the Denver office.

Very Truly Yours,

BABCOCK & WILCOX COMPANY


F.J. McGinley, Jr.
District Engineer

FJM:pm
338

IP12_011662